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CANADIAN SUPPORT PROGRAM FOR INTERNATIONAL ATOMIC ENERGY AGENCY SAFEGUARDS

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Report

CANADIAN SUPPORT PROGRAM FOR INTERNATIONAL ATOMIC ENERGY AGENCY SAFEEGUARDS

ABSTRACT

Canada has established a safeguards research and development program, the purpose of which is to supplement the resources of the IAEA. The program of support is a coordinated effort for the development and application of safeguards techniques and instruments to facilities safeguarded by the IAEA. This document sets forth the progress in the program for 1984/85.

RÉSUMÉ

Le Canada a instauré un programme de recherche et de développement en matière de garanties dont le but est de suppléer aux ressources de l'AIEA. Le programme de soutien consiste en des efforts coordonnés dans la mise au point et l'application de techniques et d'instruments de garanties pour les installations assujetties aux garanties de l'AIEA. Le présent rapport décrit le progès qui a été fait dans le programme durant 1984/85.

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INTRODUCTION

Canada supports international safeguards as a means by which the proliferation of nuclear weapons can be discouraged. Indeed, Canada was an early signatory of the Treaty of the Non-Proliferation of Nuclear Weapons (NPT) and one of the first to accept International Atomic Energy Agency (IAEA) inspection in connection with the NPT. Canada recognizes that the IAEA must have effective safeguards techniques and the active cooperation of member states. As both a user and an exporter of nuclear power reactors and nuclear materials Canada also accepts an obligation to assist the IAEA in the development and application of effective safeguards.

For many years the IAEA has pursued, within its resource limitations, solutions to a number of safeguards problems. These concerns have been described in various Agency documents in particular the Safeguards Implementation Report which identifies difficulties encountered in the achievement of technical safeguards goals and objectives which limit the degree of confidence in the conclusion of non-diversion of nuclear material. Some of these problems relate to deficiencies in the technical measures for applying safeguards for various nuclear materials and facilities. To supplement the resources of the IAEA in these areas, the Canadian Government decided to initiate a safeguards research and development program. The first phase of the program which began in 1977 concentrated on safeguards approaches for on-load fueled reactors. In 1983 the program was expanded in scope to include bulk handling facilities, future Candu fuel cycles, storage facilities, and tasks of a more general nature.

The Canadian support program is a coordinated effort for the development and the application of safeguards instruments and techniques for nuclear facilities and materials. The projects undertaken are those requested by the IAEA, and the IAEA is involved at all stages of these projects. The program encompasses research, development, and applications engineering. Modifications that must be made to facility design for the incorporation of instruments and techniques are included.

To assist the IAEA in applying equipment and techniques developed under the Support Program, Canada provides cost-free experts to the IAEA. In the past, these cost-free experts have been employed in the Division of Development and Technical Support. The expanded scope of the Safeguards Support Program allows for the provision of cost-free experts in other areas. Other expert technical assistance for seminars and training are also made available when required.

ROLE OF CANADIAN ORGANIZATIONS

The Interdepartmental Committee on Safeguards (ICS), which has representatives from the Department of External Affairs, the Atomic Energy Control Board (AECB) and Atomic Energy of Canada Limited (AECL), considers and advises on many aspects of safeguards implementation and development. On behalf of Canada the ICS reviews and approves all new proposals for tasks under the Support Program and monitors the progress of each task.

The Department of External Affairs has a role in the overall direction of the program because of its responsibilities for Canadian nuclear non-proliferation policy. The AECB is the Canadian organization most familiar with the implementation of IAEA Safeguards because of its responsibility for cooperating with

the IAEA in the implementation of the NPT safeguards agreement in Canada. AECL is the national nuclear research and development organization in Canada and has the capabilities for the development of safeguards equipment which is compatible with the design of nuclear facilities.

The AECB and AECL are jointly responsible for the administration of the Support Program. The following work is administered and funded through the AECB:

(a) provide and install safeguards equipment already agreed by Canada under the 1977 Support Program;

(b) develop safeguards schemes and techniques for other existing nuclear facilities in Canada, such as Pickering-B, Bruce-B, Darlington reactors and bulk handling facilities;

(c) recruit, train and arrange for experts to be attached to the IAEA under a Cost-Free Manpower Assistance Program;

(d) provide for travel of IAEA staff for general Support Program-related activities;

(e) provide nuclear, chemical and physical standards required by the IAEA for safeguards development and application;

(f) undertake safeguard studies;

(g) ensure that the performance objectives and proposed method of operation of safeguards equipment developed under the Support Program are practical, cost-effective and in accord with the Canadian IAEA Safeguards Agreement if Canadian facilities are involved.

The following work is administered and funded through AECL:

(a) undertake R & D on safeguards equipment for facilities;

(b) undertake R & D on advanced safeguards equipment to improve the reliability, cost-effectiveness and performance of existing safeguards equipment;

(c) undertake R & D on safeguards schemes and safeguards equipment for a possible future advanced CANDU nuclear fuel cycle;

(d) undertake other scientific studies as agreed between Canada and IAEA.

In addition, AECL will normally serve as the prime contractor to the AECB for those portions of the work administered and funded by the AECB which require design, research, development, and workshop facilities.

FINANCIAL

The Support Program covers the direct and certain overhead costs of the program tasks. Financial administration of the support program is the responsibility of the AECB and AECL.

The cost of IAEA staff travel incurred in relation to program tasks or to attend meetings which are part of this support program are paid for by Canada.

All direct costs associated with the provision of expert manpower are borne by Canada. The IAEA and the AECB have agreed on a procedure by which the IAEA recovers these costs from Canada.

PROGRAM TASKS

The IAEA and the Canadian Support Program representatives meet semi-annually to review the program and the progress on individual projects and to bring the program document up to date.

The overall objective of the program described in this document is to assist the IAEA to develop suitable safeguards systems and equipment for implementation by the IAEA. The program has been subdivided into tasks so that it will be flexible and can be easily expanded or modified in the light of experience and changing requirements. Formal addition of new tasks to the program normally takes place at the semi-annual meetings between the IAEA and Canada. The list of approved tasks is limited to those that can be started within two years from the nominal issuance of the list.

This document presents the project tasks in four categories: manpower assistance, system studies, equipment, and miscellaneous. The manpower assistance section includes cost-free experts and technical experts and technical expert assistance in the form of seminars and training. The tasks in the system studies section include the development of safeguards system concepts. The equipment section deals with tasks related to equipment specially designed for particular facilities. The fourth category, miscellaneous, is for those tasks, such as the provision of physical standards, which do not fit into one of the previous three groups.

SUMMARY OF PROGRESS DURING 1984/85

The details of progress on each task during 1984/85 including expenditure of funds is attached. Highlights of the program according to groups of tasks are provided in the following:

1. Manpower Assistance

The Agency has expressed a high degree of satisfaction with the cost-free expert program and indicated that the successful assimilation of equipment developed by Canada was expedited by the efforts of CFEs 2 and 3. In particular these two CFEs have trained operators and maintainers in the operation and use of equipment. Substantial contributions to determine equipment failure modes and to improve equipment performance have been made. CFE-1 has provided particular support in the interpretation by Operations staff of the results obtained from the implementation of safeguards schemes. Safeguards schemes for two types of research reactors were drafted. A seminar on safeguarding CANDU reactors was particularly well received by IAEA personnel. A multiplexed CCTV system and a model for a spent fuel sealing system were delivered to the IAEA for training inspectors. A performance monitoring program has continued to provide information on the reliability of equipment developed by Canada and used by the IAEA. The IAEA will expand this program to include all equipment used by the IAEA.

Total expenditure $401,000.

2. System Studies

Assistance was provided to the IAEA to prepare safeguards schemes for NRX- and NRU-type reactors. A draft scheme for NRX-type reactors has been distributed in the Agency for review and comment. The study will be used by the IAEA in negotiating safeguards arrangements for this type of facility. Assistance has also been provided to the IAEA regarding interpretation of safeguards schemes for CANDU reactors by Agency inspectors.

Total expenditure $3,000.

3. Equipment

3.1 General:

Equipment developed under the Support Program for use at facilities undergoes a review process by the appropriate facility operators. The review addresses safety - both nuclear and occupational - operational, and installation concerns. The review process is initiated prior to introduction of equipment at a facility. Attempts are made to inform facility operators of equipment development at an early stage to obtain their input, so that operator acceptance of the finished product is reasonably assured. This has been particularly important when equipment is permanently installed at a facility, which has been the case for bundle counters and surveillance equipment.

3.2 Bundle Counters:

Bundle counters have been installed in four CANDU 600s. Technical problems have been encountered with these counters resulting in "sequence errors" detected by

the bundle counter software. These sequence errors did not, however, result in the inability of the bundle counters to count the flow of bundles from the reactor core to the spent fuel bay. A reduction in the number of sequence errors recorded by the spent fuel bundle counters has been achieved by the installation of heavy metal geiger assemblies, using a tungsten alloy called Kennertium and new water tight connectors.

Collimators, electronics, and spare parts for two bundle counters to be deployed at a 125 Mw CANDU reactor were delivered to the IAEA, who will arrange for their installation.

Electronics spare parts and a tester unit were delivered to the IAEA for three bundle counters to be installed at a 200 Mw CANDU reactor. Collimators for these bundle counters were designed and manufacturing drawings were delivered to the IAEA, who will arrange for the manufacture and installation of the collimators.

Preparations have been completed for the installation of Bruce A spent fuel bundle counters, and arrangements are being made for their installation. The IAEA, using the Bruce A design, purchased and installed bundle counters for the Bruce B station before that station began operation.

Spent fuel bundle counters for Pickering A and B have been requested by the IAEA. The design of these counters has begun.

The fresh fuel bundle counter developed for Bruce A at the request of the IAEA, underwent field trials at Bruce A. The trials were successful and four such devices were manufactured. However, the IAEA is reexamining the safeguards role of the devices and a decision of their installation is awaited.

All bundle counters have been designed not to interfere with the normal flow of bundles through the transport system and are independent of station power.

3.3 Sealing Systems:

A demonstration/training exercise using both optical and ultrasonic seals was conducted at the NPD reactor involving CRNL and IAEA personnel. The exercise resulted in changes to operating procedures and manuals. A report on the status of development of the ultrasonic seal has been started with the aim of indicating the suitability of the seal for safeguards application. The only additional work planned for ultrasonic seals is to prove out the existing designs.

Attempts to reproduce the zirconium identity element of the optical seal were not successful. The work on zirconium elements was dropped in favor of using high purity (99.99%) crystalline aluminum identity elements because of problems encountered in reproducing large grains in the zirconium element. However, potential corrosion problems for the aluminum identity element must be overcome. The illumination and CCTV system has been redesigned to produce clearer and more reproductible images of the seal identity. The seal has been demonstrated in the laboratory and full scale testing at NPD is required to demonstrate the applicability of the system for safeguards use.

A third alternative seal, the x-cap seal, is being developed which employs the x-type seal used by the IAEA. Tooling has been constructed for use with this

seal. Questions regarding decontamination and corrosion are being investigated. A new specification for the metal of the x-type seal has been recommended to the IAEA to reduce corrosion.

A trial application of the containment structure was performed at one reactor facility on simulated stacks of fuel in air. This was done to enable the reactor operator to evaluate the procedures for installation of the containment structure and the deployment of ultrasonic seals on stacks of fuel in the spent fuel bay. The trial was successful with the exception that the stack covers require redesign.

Field trials of all three seals are planned for 1985/86. The IAEA has emphasized the need for implementation of a spent fuel sealing system at an early date.

Total expenditure $1,215,000.

3.4 Surveillance Devices:

The original CCTV system did not meet IAEA requirements with respect to reliability and efforts were begun in 1983/84 to develop a replacement. This work was continued in 1984/85 and a multiplexed (MUX) CCTV system was developed, which passed preliminary testing by the IAEA in Canada and was delivered to the IAEA for further evaluation and training of inspectors. Software specifications for a monitoring system for the MUX CCTV hardware were recommended to the IAEA. Backup TLRs were installed in three facilities so that all 600 MW CANDU reactors had reliable CCTV systems.

The new CCTV system should be considerably less costly than the original CCTV system, more reliable and easier to maintain than either the original CCTV system or a system using one dedicated TLR for each camera.

Total expenditure $474,000.

3.5 Verifiers:

Documentation on the optical tool for Bruce A was completed. Two new Cerenkov viewing devices (CVD) were manufactured and tested. These devices have been shown to have improved sensitivity over earlier devices. The CVD using the mirror lens is preferable to the more expensive quartz lens in terms of performance and cost. The IAEA has shown considerable interest in the CVD development effort.

Total expenditure $74,000.

3.6 Miscellaneous:

Warranty work continued in 1984/85 on all installed 600 MW safeguards equipment. This effort is expected to be reduced significantly in 1985/86.

Total expenditure $365,000.

RK6/01

DESCRIPTION OF TASKS

MANPOWER ASSISTANCE

Two types of projects are advanced in this section: cost-free experts (CFE) and engineering and scientific support (ESS). A cost-free expert in this program is a Canadian on the staff of the IAEA under the terms of a special services agreement, all direct IAEA costs being reimbursed by Canada. The engineering and scientific support is primarily directed to the training of Agency personnel in the use of equipment developed under the program; to providing Agency personnel with an understanding in the operation of facilities of which Canada has particular expertise; and to assisting the Agency to apply safeguards schemes and equipment developed under the program.

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: CFE-1

TITLE: Safeguards System Analyst

PARTICIPATING ORGANIZATIONS: AECB

IAEA PROJECT OFFICER: V. Pushkarjov

PROBLEM:

To develop and evaluate proposals for safeguards systems to be applied to OLRs.

PROPOSED SOLUTION:

Provide a Cost-Free Expert to:

1) Review Design Information
2) Make proposals for safeguards systems
3) Evaluate proposed safeguards systems
4) Develop criteria for safeguards system suited to OLRs
5) Liaise on system studies tasks

SCHEDULE AND MILESTONES:

Three cost-free experts have been consecutively supplied to serve on IAEA staff. The first cost-free expert was supplied to serve on IAEA staff in July 1978. A third expert is currently serving on staff having begun a two-year assignment in August 1983.

PROGRESS:

Safeguards schemes for Bruce-type, Pickering-type, 600 MW type and 125 MW-type CANDU reactors have been completed. Work is continuing on other CANDU reactor systems, including research reactors. In the current year a report has been drafted to assist inspectors in the interpretation of results of the 600 MW safeguards scheme on the basis of experience gained during implementation; a draft safeguards scheme for NRX-type research reactors has been issued for review and comment; a seminar on CANDU reactor safeguards was presented; the module for on-load-fuelled reactors for the inspector training courses was revised and presented and general assistance was provided to the IAEA regarding OLR safeguards.

PLANNED COMPLETION DATE:

Continuing

FUNDING:

Through 1983/84 -	$	474,000
1984/85 -	$	80,000
1985/86 -	$	130,000
1986/87 -	$	90,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: CFE-2

TITLE: CANDU Safeguards Instrumentation Expert

PARTICIPATING ORGANIZATIONS: AECB

IAEA PROJECT OFFICER: D. Rundquist

PROBLEM:

The IAEA requested assistance in the development of instrumentation for safeguarding CANDU reactors.

PROPOSED SOLUTION:

Supply a cost-free expert to serve on IAEA staff to:

1) Collaborate with IAEA staff in developing criteria for instrument performance
2) Collaborate with IAEA staff in determining needs for new instrumentation
3) Develop instruments as required, and participate in testing and evaluation
4) Interact with Canadian Support Program Office on task ESS-2

SCHEDULE AND MILESTONES:

The expert currently at IAEA headquarters began his three year assignment in October, 1982.

PROGRESS:

Work to date has involved the development of CCTV systems, film cameras, ultrasonic seals, and bundle counters. Performance monitoring and training programs covering this equipment have been established. During the current year the performance monitoring program has matured to the stage where inspectors are collecting the data. The program should be turned over to the IAEA Technical Services Section in 1985/86. A report on the experience with the 600 MW safeguards equipment was written. Contributions were made in the CANDU safeguards seminar. Assistance in training inspector and maintenance personnel on the use and operation of safeguards equipment was provided.

PLANNED COMPLETION DATE:

October, 1985

FUNDING:

Through 1983/84 -	$	272,000
1984/85 -	$	84,000
1985/86 -	$	106,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: CFE-3

TITLE: CANDU Safeguards Implementation Expert

PARTICIPATING ORGANIZATIONS: AECB

IAEA PROJECT OFFICER: D. Rundquist

PROBLEM:

The IAEA requested assistance with regard to design of CANDU power stations and research reactors to assist the implementation of safeguards equipment and ensure that a good knowledge of CANDU designs rests with the IAEA.

PROPOSED SOLUTION:

Supply a cost-free expert to serve on IAEA staff to:

1) Review design information now available with the IAEA
2) Recommend acquisition of additional data where required
3) Assist IAEA staff in the preparation of safeguard techniques and procedures
4) Assist IAEA staff in the preparation of instrument operation, and maintenance manuals

SCHEDULE AND MILESTONES:

The expert currently serving on IAEA staff began a two year assignment in February, 1983. The assignment was extended one year.

PROGRESS:

The work on this task lead to the successful installation and commissioning of the safeguards instrumentation for the CANDU 600 reactors. The current expert has been involved in the preparation of performance monitoring checklists and operating manuals and revision of safeguards schemes to reflect actual conditions and equipment performance. The performance monitoring activities are finalized. Review of the 600 MW CANDU diversion paths was undertaken and presented in the CANDU safeguards seminar. Several performance monitoring visits were undertaken and important feedback was given to equipment developers.

PLANNED COMPLETION DATE:

February, 1986

FUNDING:

Through 1983/84 -	$	249,000
1984/85 -	$	72,000
1985/86 -	$	88,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: ESS-1

TITLE: Seminars on Aspects of CANDU reactors

PARTICIPATING ORGANIZATIONS: AECL/AECB/Ontario Hydro

IAEA PROJECT OFFICER:

PROBLEM:

Detailed information available to the IAEA on CANDU power stations was such that an understanding of safeguards schemes for these stations was not fully realized.

PROPOSED SOLUTION:

1) Provide the IAEA with a summary of information relevant to CANDU reactors.
2) Provide courses of instruction and seminars in Vienna on various aspects of CANDU power stations.

SCHEDULE AND MILESTONES:

Provide seminars as required on a non-routine basis.

PROGRESS:

A series of seminars on the various aspects of CANDU reactors was given in October 1981 in Vienna. Videotapes were made in order to make the information presented available to a greater number of IAEA personnel. The lectures given have been assembled and bound into a report (WNRE-521). Several copies were sent to the IAEA. In November 1984 a three-day seminar was given to IAEA staff by the three Cost-Free Experts. This was a concentrated seminar stressing reactor operation, identification of safeguards equipment and its use, interpretation of results of the safeguards scheme and the importance of performance monitoring. A summary version of that course was given to IAEA safeguards Management in February 1985.

PLANNED COMPLETION DATE:

Continuing.

FUNDING:

Through	1983/84 - $	17,000
	1984/85 - $	0
	1985/86 - $	0

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: ESS-2

TITLE: Training for Use of Safeguards Equipment

PARTICIPATING ORGANIZATIONS: AECB/AECL

IAEA PROJECT OFFICER:

PROBLEM:

Inspectors must be made aware of and trained in the use of new equipment developed by the Support Program so that the equipment is used in an effective manner.

PROPOSED SOLUTION:

1) Assist in preparing manuals and training aids.
2) Assist in conducting training courses to instruct inspectors.

SCHEDULE AND MILESTONES:

Continuing, as required.

PROGRESS:

A manufacturer's representative was on hand at IAEA headquarters, Vienna to provide information and training on the Canadian built film cameras. A film camera unit remains at IAEA headquarters to provide inspectors with hands-on training and experience.

A 600 MW bundle counter was shipped to the IAEA headquarters, Vienna in 1980 August. Training in the use and maintenance of this equipment began in September that year and the equipment remains at IAEA headquarters to provide inspectors with hands-on training and experience. AECL assisted the IAEA in preparing a training film on this counter.

Training of several IAEA inspectors in the operation of the CCTV equipment took place early in 1981 in Canada, at the manufacturer's works. An operational CCTV unit was available at the IAEA headquarters in Vienna prior to installation at a power reactor to provide inspectors and maintenance personnel with hands-on training and experience.

Since May 1983, training exercises have been given in the field to pairs of inspectors on many occasions for the above equipment items.

PROGRESS:

During 1984/85 a demonstration/training exercise was performed to acquaint and train inspectors on the application of ultrasonic seals to spent fuel stacks underwater. A model for sealing stacks of fuel was delivered to the IAEA for inspector training. A multiplexed CCTV system was delivered to the IAEA for evaluation and training inspectors in its operation.

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

PLANNED COMPLETION DATE:

Continuing, as required.

FUNDING:

Through 1983/84 -	$	25,000
1984/85 -	$	61,000
1985/86 -	$	30,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: ESS-3

TITLE: Attendance at Technical Meetings

PARTICIPATING ORGANIZATIONS: AECB/AECL/IAEA

IAEA PROJECT OFFICER:

PROBLEM:

IAEA staff need to consult with Canadian safeguards staff on technical matters relating to CANDU safeguards. This is best done by attending task force or working party meetings.

PROPOSED SOLUTION:

Fund IAEA participation in technical meetings concerned with tasks of the Safeguards Support Program.

SCHEDULE AND MILESTONES:

Continuing, as required.

PROGRESS:

Funds are authorized as required on a non-routine basis for IAEA personnel required for attendance at technical meetings.

PLANNED COMPLETION DATE:

Continuing, as required.

FUNDING:

Through 1983/84 -	$	138,200
1984/85 -	$	17,000
1985/86 -	$	20,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: ESS-4

TITLE: Review and Interpretation of Surveillance Records

PARTICIPATING ORGANIZATIONS: IAEA/AECB/AECL

IAEA PROJECT OFFICER:

PROBLEM:

The Agency requires assistance in training inspectors in the interpretation of surveillance records for CANDU reactors including the 600 MW CANDUs. The training film should illustrate routine operations occurring at the reactor facilities.

PROPOSED SOLUTION:

A feasibility study will be conducted to determine if a film of routine fuel handling operations can be made based on existing routine surveillance films or whether purpose-made films are required. The routine movements would include both fuelling and maintenance activities.

If feasible a review of surveillance films from Canadian facilities provided by the Agency will be made to select those portions which indicate typical routine movements. These portions will be put on a single tape with a description of the events that are occurring. If required these films may be supplemented by purpose-made films to show the entire sequence of each routine operation.

SCHEDULE AND MILESTONES:

Begin: Feasibility
Complete: (6 months after start)

PLANNED COMPLETION DATE:

TBD

FUNDING:

1985/86 - $ 20,000

SYSTEM STUDIES

Project tasks which fall into this section are those which relate to the determination of what would constitute an acceptable or adequate safeguards system for a particular type of facility. These projects are related to concepts rather than equipment. There are at least two steps required before a safeguards system can be put in place: the diversion analysis and the system design. While general rules may be applied, each facility type must be examined and considered individually.

System studies tasks relating to the 600 MW design have been undertaken and completed prior to the implementation of the support program. A diversion path analysis and a safeguards scheme were produced and provisionally accepted with minor modification by the IAEA. Equipment tasks relating to the 600 MW reactor were derived from the CANDU 600 system studies. .

The tasks in this group are studies undertaken in cooperation with the IAEA. The actual implementation of a safeguards regime at a facility will depend upon agreements reached between the IAEA, the country in which the facility is located, and the facility operator.

CANADIAN SAGEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: S-2

TITLE: Development of a Safeguards Scheme for NRX-type reactors

PARTICIPATING ORGANIZATIONS: AECB

IAEA PROJECT OFFICER:

PROBLEM:

A design for an integrated safeguard system is needed as a complement to IAEA inspection activities to provide a full safeguards package for NRX type research reactor.

PROPOSED SOLUTION:

To assist the IAEA to:

1) Compile design information
2) Produce a diversion analysis
3) Produce a safeguards scheme

SCHEDULE AND MILESTONES:

1) Begin September 1981
2) Produce a first draft for a safeguards scheme April 1983
3) Produce a second draft safeguards scheme June 1985
4) Produce a final safeguards scheme December 1985

PROGRESS:

Recommendations have been made for updating of safeguards at these reactors. The recommendations are currently being assessed with respect to their practical implementation by reactor operators and instrumentation specialists. A safeguard scheme has been drafted and issued for review and comment within the IAEA.

PLANNED COMPLETION DATE:

December 1985

FUNDING:

Through 1983/84 - $ 1,000
1984/85 - $ 1,000
1985/86 - $ 0

CANADIAN SAGEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: S-7

TITLE: Development of a Safeguards Scheme for NRU-type Reactors

PARTICIPATING ORGANIZATIONS: AECB/AECL

IAEA PROJECT OFFICER:

PROBLEM:

A design for an integrated safeguards system for the NRU- type reactor is needed to complement the IAEA inspection activities to provide a comprehensive safeguards scheme for this type of reactor.

PROPOSED SOLUTION:

Assist the IAEA to:

1) Compile design information
2) Produce a diversion path analysis
3) Perform feasibility studies by providing technical assistance
4) Produce a safeguards scheme
5) Determine equipment needed for this safeguards scheme.

SCHEDULE AND MILESTONES:

Begin May 1982, complete 1985.

PROGRESS:

CFE-1 visited Canada to study this type of reactor in May, 1981 and June, 1983. Design information has been compiled and sent to the IAEA. The design information has been reviewed and a draft safeguards scheme is currently being prepared. The recommendations for the scheme must be assessed for their practical implementation by reactor operators and instrumentation specialists. A draft safeguards scheme is nearing completion and should be issued for internal IAEA comment and review in 1985.

PLANNED COMPLETION DATE

April, 1985

FUNDING:

Through 1983/84 - $ 0
1984/85 - $ 2,000
1985/86 - $ 0

CANADIAN SAGEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: S-8

TITLE: Safeguards Scheme for Darlington

PARTICIPATING ORGANIZATIONS: IAEA/AECB

IAEA PROJECT OFFICER:

PROBLEM:

A safeguards system is required for the Darlington reactor facility.

PROPOSED SOLUTION:

Determine applicability of the Bruce A safeguards system to the Darlington facility by assisting the IAEA to:

1) Assemble appropriate information for Darlington
2) Determine if the safeguards scheme and equipment for Bruce A can be used for Darlington
3) Determine, if necessary, what changes in the Bruce A scheme or equipment would have to be made to allow them to be applied at Darlington

SCHEDULE AND MILESTONES:

1) Compile information for Darlington, March 1985.
2) Compare Darlington and Bruce A designs, November 1985.
3) Determine differences in the scheme required for Darlington, February 1986.
4) Identify what design changes to the safeguards equipment designed for Bruce or to Darlington itself would be needed to adapt the Bruce scheme to Darlington. (A decision on proceeding with designing the necessary changes would be required before any redesign work is actually done.)
5) Write a report on the work done.

PLANNED COMPLETION DATE:

Complete milestone 3) February 1986.

FUNDING:

Through 1984/85 - $ 1,000
1985/86 - $ 0

EQUIPMENT

Most of the equipment developed or under development fits into the category of containment and surveillance devices. Their use in safeguards can serve both to improve the assurance of non-diversion and to reduce the personnel requirements of the IAEA which has limited manpower resources.

Although the principles of operation of various kinds of safeguards equipment may be generally applicable, the specific design may be influenced by the facility type or even the individual facility design. Such equipment includes the bundle counter collimators, covers and seals, and the irradiated fuel verifier. Indeed much of this equipment may not be interchangeable from facility to facility, since not only will it be engineered to fit into a particular reactor type but also there are often minor differences between reactors within one type.

There are other pieces of equipment for which the design will be much less facility dependent. TV surveillance cameras and yes-no monitors fall into this category. In some cases assistance with the acquisition of this sort of equipment will be given under this support program.

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: B-2

TITLE: Provision of Bundle Counters for four 600 MW CANDU Stations

PARTICIPATING ORGANIZATIONS: AECL-CRNL

IAEA PROJECT OFFICER: A. Keddar

PROBLEM:

The Agency requires counters for spent fuel bundles discharged from four 600 MWe CANDU reactors.

PROPOSED SOLUTION:

Manufacture, install and commission the bundle counters.

SCHEDULE AND MILESTONES:

Start manufacture	: 1978
Complete installation	: 1983
Complete commissioning	: 1984
Deficiencies corrected	: 1986

PROGRESS:

The bundle counters have been installed and are operating at all four reactors. A training unit has been provided to the Agency. IAEA and AECL staff have monitored the performance of the counters. Erroneous messages have occurred occasionally but the causes have been determined and corrective action has been taken. The lead shielding in some collimators appears to be moving out of place. Modifications will be carried out in 1985 to correct this problem. An improved design of the doors was begun. New doors will be installed on all bundle counter electronics cabinets in 1986.

PLANNED COMPLETION DATE:

1986

FUNDING:

Through 1983/84	- $	720,000
1984/85	- $	281,000
1985/86	- $	90,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: B-3

TITLE: Provision of Bundle Counter for Bruce-A Station

PARTICIPATING ORGANIZATIONS: AECL-CRNL

IAEA PROJECT OFFICER: A. Keddar

PROBLEM:

The Agency requires counters for spent fuel bundles discharged from the Bruce-A CANDU reactors.

PROPOSED SOLUTION:

Design, manufacture, install and commission the bundle counters. Except for software, the electronics and detectors will be the same as those at the 600 MWe CANDU stations.

SCHEDULE AND MILESTONES:

Design	: 1980-1983
Complete manufacture	: 1984
Complete documentation	: 1985
Complete installation	: 1985
Complete commissioning	: 1986

PROGRESS:

The collimators have been manufactured and delivered to the site. Existing framework around each of four fuel transfer ports must be removed and replaced with new framework incorporating the collimators. This work will be carried out by the facility operator. The electronics are completed. Manufacture of the detectors is completed.

PLANNED COMPLETION DATE:

1986

FUNDING:

Through 1983/84 - $	730,000
1985/85 - $	186,000
1985/86 - $	45,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: B-4

TITLE: Provision of Bundle Counters for Pickering-A Station

PARTICIPATING ORGANIZATIONS: AECL-CRNL

IAEA PROJECT OFFICER: A. Keddar

PROBLEM:

The Agency requires counters for fuel bundles discharged from the Pickering-A CANDU reactors.

PROPOSED SOLUTION:

Design, manufacture, install and commission the bundle counters. Except for software, the electronics and detectors will be the same as those at the 600 MWe CANDU stations.

SCHEDULE AND MILESTONES:

Design	:	1980-1984
Complete manufacture	:	1985
Complete installation	:	1985
Complete commissioning	:	1986
Complete documentation	:	1986

PROGRESS:

Manufacture of the electronics is complete. A preliminary design for the collimators was rejected by the facility operator because of installation problems. Work has begun on an alternative design based on a different location of the geiger detectors.

PLANNED COMPLETION DATE:

1986

FUNDING:

Through 1983/84	- $	170,000
1984/85	- $	108,000
1985/86	- $	155,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: B-5

TITLE: Provision of Bundle Counters for 125 MW CANDU Station

PARTICIPATING ORGANIZATIONS: AECL-CRNL

IAEA PROJECT OFFICER: A. Keddar

PROBLEM:

The Agency requires counters for spent fuel bundles being discharged from a 125 MWe CANDU reactors.

PROPOSED SOLUTION:

Design and manufacture the bundle counter adapting the concept developed for the 600 MWe reactors to suit the 125 MWe reactor.

SCHEDULE AND MILESTONES:

Start and complete design	:	1982
Complete manufacture	:	1982
Ship to IAEA	:	1982
Supply spare parts and final documentation	:	1985

PROGRESS:

The bundle counter was completed and shipped to the IAEA. Spare parts and documentation have been provided. Final documentation remains to be completed. Cabinet doors of an improved design will be provided.

PLANNED COMPLETION DATE:

1985

FUNDING:

Through 1983/84 -	$	160,000
1984/85 -	$	3,000
1985/86 -	$	39,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: B-6

TITLE: Provision of Bundle Counters for 200 MW CANDU Station

PARTICIPATING ORGANIZATIONS: AECL-CRNL

PROJECT OFFICER: A. Keddar

PROBLEM:

The Agency reqires assistance in the design of a counter for spent fuel bundles being discharged from a 200 MWe CANDU reactor, particularly with respect to physics calculations for the collimators and software for the electronics.

PROPOSED SOLUTION:

Design collimators and software to meet the specific technical conditions at the station. Manufacture special circuitry and spare parts.

SCHEDULE AND MILESTONES:

Start and complete design : 1983
Supply spare parts and final documentation: 1985

PROGRESS:

The collimators were designed and the software completed. A special tester was manufactured to check the performance of the electronics unit. Spare parts and documentation have been provided. The electronics were manufactured. All equipment was shipped to the IAEA and installed. Cabinet doors of an improved design will be provided.

PLANNED COMPLETION DATE:

1985

FUNDING:

Through 1983/84 - $ 330,000
1984/85 - $ 11,000
1985/86 - $ 20,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: B-7

TITLE: Engineering Assistance for Bundle Counters for Bruce-B Station

PARTICIPATING ORGANIZATIONS: AECL-CRNL

IAEA PROJECT OFFICER: A. Keddar

PROBLEM:

The Agency requires engineering assistance in the design, development, installation and commissioning of spent fuel bundle counters for the Bruce-B station.

PROPOSED SOLUTION:

Provide assistance as required. The basic concept developed for the 600 MWe CANDU reactors is being adapted to meet the requirements specific to Bruce-B.

SCHEDULE AND MILESTONES:

Start task : 1984
Complete installation : 1984
Complete commissioning: 1985

PROGRESS:

The bundle counters have been installed and are operating satisfactorily. The only deficiency, a minor one, will be corrected by software change. Engineering assistance was given to design the installation for the bundle counters. The assistance was funded by the IAEA.

PLANNED COMPLETION DATE:

1985

FUNDING:

Through 1983/84 - $ 0
1984/85 - $ 0

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: B-8

TITLE: Engineering Assistance for Bundle Counters for Pickering-B Station

PARTICIPATING ORGANIZATIONS: AECL-CRNL-CANDU OPS

IAEA PROJECT OFFICER: A. Keddar

PROBLEM:

The agency requires engineering assistance in the design, development, installation and commissioning of spent fuel bundle counters for the Pickering-B station.

PROPOSED SOLUTION:

Provide assistance as required. The basic concept developed for the 600 MWe CANDU reactors is being adapted to meet the requirements specific to Pickering-B.

SCHEDULE AND MILESTONES:

Start task	:	1984
Complete installation	:	1985
Complete commissioning	:	1986

PROGRESS:

The electronics have been manufactured outside the Support Program. The detailed design for the collimators and the design of the installation has begun and is part of the Support Program. Supply of collimators and geiger detectors is outside the Support Program.

PLANNED COMPLETION DATE:

1986

FUNDING:

Through 1983/84	- $	0
1984/85	- $	0
1985/86	- $	115,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: B-9

TITLE: Bundle Movement Simulator

PARTICIPATING ORGANIZATION: IAEA/AECL/AECB

IAEA PROJECT OFFICER:

PROBLEM:

The IAEA has identified a requirement for both training and troubleshooting purposes to have a bundle movement simulator with the ability to turn geiger currents on and off individually in any sequence and for durations of time ranging from fractions of a second to continuous. Such a simulator would enable the IAEA to demonstrate to inspectors the response of the bundle counter to such situations as:

1) A geiger tube failed permanently in the conducting state,
2) A geiger tube failure in the open circuit state,
3) Intermittent "on" and "open" circuit geiger states,
4) Unusual fuel discharge events.

PROPOSED SOLUTION:

1) Determine the feasibility of constructing the simulator,
2) Design, build and test the simulator.

SCHEDULE AND MILESTONES:

1) Determine feasibility of constructing the simulator,
2) Determine the cost of developing and constructing the simulator,
3) Develop and construct the simulator,
4) Test simulator,
5) Document the work, including operating and maintenance manuals,
6) Deliver simulator to IAEA.

PROGRESS

PLANNED COMPLETION DATE:

1986

FUNDING:

1985/86 - $ 23,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: C-1

TITLE: Development of a Sealing System for the 600 MW CANDU Reactor Storage Bay

PARTICIPATING ORGANIZATIONS: AECL-CRNL

IAEA PROJECT OFFICER: R. Dennys

PROBLEM:

Large numbers of spent fuel bundles accumulate in CANDU reactor spent fuel bays. It would be a difficult and time-consuming task to count and verify the bundles during a physical inventory verification at a CANDU station.

PROPOSED SOLUTION:

Develop a system for the 600 MWe CANDU stations to seal the spent fuel in storage racks. The sealing system will complement the surveillance system to provide continuity of knowledge regarding the nuclear material inventory. Sealing systems for other CANDU stations will be based on the experience gained at the 600 MWe stations.

SCHEDULE AND MILESTONES:

Start development: 1977
Complete development: 1986
Complete documentation: 1986

PROGRESS:

AECL and ISPRA cooperated in the development of a seal based on ultrasonic detection of random metal inclusions in the seal body. Tests of the seal demonstrated that it was not suitable for routine use without further development.

AECL in liaison with SANDIA then developed a cap seal based on ultrasonic measurements of a random coil.

Random coil cap seals, installation and removal tools, and the ultrasonic reading equipment have been tested and demonstrated at NRU and NPD. Further tests will be conducted to determine the long term reproducibility of the seal signatures.

PLANNED COMPLETION DATE:

1986

FUNDING:

Through 1983/84 -	$	1,460,000
1984/85 -	$	331,000
1985/86 -	$	80,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: C-2

TITLE: Provision of Sealing Systems for the Four 600 MW Station Storage Bays

PARTICIPATING ORGANIZATIONS: AECL-CRNL-CANDU OPS

IAEA PROJECT OFFICER: R. Dennys

PROBLEM:

A sealing system is required for the fuel in the spent fuel storage bay at each of four 600 MWe CANDU stations.

PROPOSED SOLUTION:

Design and manufacture the equipment required. The sealing system is based on connecting trays of spent fuel bundles together with rods and then sealing the rods in place with cap seals.

SCHEDULE AND MILESTONES:

Complete supply of stacks and rods	: 1983
Complete demonstration and acceptance of seal	: 1985
Begin field use of sealing system	: 1986

PROGRESS:

The fuel stacks, covers and rods have been designed and manufactured. A dry trial of two simulated stacks of spent fuel showed that the covers need to be modified to accommodate greater offset of the stacked trays than was allowed for in the design of the covers. Three types of cap seals have been developed and are being tested: the random coil "ultrasonic" seal, the metallic crystal "optical" seal and the "X-cap" seal. Field trial of the sealing system by the IAEA is expected to begin in 1985.

PLANNED COMPLETION DATE:

1986

FUNDING:

Through	1983/84 - $	350,000
	1984/85 - $	498,000
	1985/86 - $	355,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: C-3

TITLE: Development of a Sealing System for the Irradiated Fuel Storage Bays for existing Canadian Supplied Reactors

PARTICIPATING ORGANIZATIONS: AECL-CRNL

IAEA PROJECT OFFICER: R. Dennys

PROBLEM:

The Agency needs a sealing system for the spent fuel bays of existing Canadian supplied CANDU reactors.

PROPOSED SOLUTION:

Assist the Agency in designing and producing the equipment required for each particular reactor.

SCHEDULE AND MILESTONES:

Specify the scope of the task: 1985

PROGRESS:

No detailed work is planned until some experience has been gained with the use of seals in the 600 MWe CANDU spent fuel bays.

PLANNED COMPLETION DATE:

Not established.

FUNDING:

Through 1983/84 - $ 26,000
1984/85 - $ 0
1985/86 - $ 0

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: C-4

TITLE: Provision of a Sealing System for the Bruce-A Auxiliary Storage Bay

PARTICIPATING ORGANIZATIONS: AECL-CRNL

IAEA PROJECT OFFICER: R. Dennys

PROBLEM:

The Agency needs a sealing system for the fuel in the auxiliary spent fuel storage bay at the Bruce A station.

PROPOSED SOLUTION:

Design and manufacture the equipment for sealing the spent fuel.

SCHEDULE AND MILESTONES:

Start design: 1979

PROGRESS:

The stacks and covers have been designed. Twenty covers have been manufactured. After manufacture, the stacking frame dimensions were changed. Modifications must be designed and made. Provision of the equipment will occur after the sealing concept has been proven at the 600 MWe CANDUs.

PLANNED COMPLETION DATE:

1986

FUNDING:

Through 1983/84 -	$	94,000
1984/85 -	$	20,000
1985/86 -	$	10,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: C-5

TITLE: Provision of a Sealing System for the Pickering-A Storage Bay

PARTICIPATING ORGANIZATIONS: AECL-CRNL

IAEA PROJECT OFFICER: R. Dennys

PROBLEM:

The Agency needs a sealing system for the fuel in the spent fuel storage bay at the Pickering A station.

PROPOSED SOLUTION:

Design and manufacture the equipment for sealing the spent fuel.

SCHEDULE AND MILESTONES:

Start design: 1977
Install sealing equipment: 1986

PROGRESS:

The stacks and covers have been designed. Provision of the equipment will occur after the sealing concept has been proven at the 600 MWe CANDUs.

PLANNED COMPLETION DATE:

1986

FUNDING:

Through 1983/84	- $	28,000
1984/85	- $	0
1985/86	- $	10,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: C-6

TITLE: Development of Alternative Seals for Spent Fuel Storage Bays

PARTICIPATING ORGANIZATIONS: AECL-CRNL

IAEA PROJECT OFFICER: R. Dennys

PROBLEM:

The development of ultrasonic seals for use on stacks of CANDU fuel bundles in spent fuel storage bays has evolved into larger program than originally anticipated. There is a need for investigation of alternative approaches for seals that may be more readily applied in the field.

PROPOSED SOLUTION:

To offset the possibility that ultrasonic seals may not meet the Agency's requirements including tamper resistance, underwater seals based on other technologies are being developed.

An optical seal based on the unique crystal patterns and a seal incorporating the Agency's X-type seal are being proposed.

SCHEDULE AND MILESTONES:

Start task	:	1984
Demonstrate the sealing concepts	:	1984
Complete development	:	1985
Complete field demonstration	:	1986

PROGRESS:

Optical seals based on identities of crystalline zirconium were developed, but their manufacture in large quantities presented difficulties. Work on the use of crystalline "Superpure" aluminum appears promising.

A new specification for the material for the top of the X-type seal was recommended to the IAEA. The designs for the tools for the application, verification and removal of the optical and X-type seals have been completed.

Tests of both types of seals in reactor spent fuel storage bays are expected to begin in the fall of 1985.

PLANNED COMPLETION DATE:

1986

FUNDING:

Through 1983/84	- $	500,000
1984/85	- $	367,000
1985/86	- $	251,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: V-2

TITLE: Provision of Irradiated Fuel Verifiers for Four 600 MW CANDU Stations

PARTICIPATING ORGANIZATIONS: AECL/AECB

IAEA PROJECT OFFICER:

PROBLEM:

Provision of irradiated fuel verifiers for four 600 MWe CANDU stations.

PROPOSED SOLUTION:

1) Ensure design of prototype (V-8) is adequate
2) Modify if required to suit particular installations
3) Construct four sets of verifiers
4) Provide design, operation and maintenance manuals
5) Provide a training program for IAEA staff on the operation of the equipment

SCHEDULE AND MILESTONES:

Begin July 1983, complete December 1985

PROGRESS:

Three versions of night viewing devices for observing the Cerenkov radiation have been manufactured. The testing of these verifiers will be completed in 1985. A decision will be made on the most applicable device for use at the reactor facilities.

PLANNED COMPLETION DATE:

December 1985

FUNDING:

Through 1983/84	- $	84,000
1984/85	- $	32,000
1985/86	- $	0

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: V-3

TITLE: Provision of Irradiated Fuel Verifiers for Existing Canadian Supplied Reactors

PARTICIPATING ORGANIZATIONS: AECL/AECB

IAEA PROJECT OFFICER:

PROBLEM:

Provision of irradiated fuel verifiers for existing Canadian supplied reactors.

PROPOSED SOLUTION:

To assist the IAEA to produce an irradiated fuel verifier suited to irradiated fuel storage bays at CANDU reactors. Such devices must be designed to suit the particular parameters of each storage bay. The agency will be assisted to:

1) Design verifiers and tools
2) Construct verifiers and tools

SCHEDULE AND MILESTONES:

As requested by the IAEA.

PROGRESS:

The scope of this task is still under discussion with the IAEA and is pending development of safeguards schemes for the reactors in question and completion of task V-8.

PLANNED COMPLETION DATE:

TBD

FUNDING:

Through 1983/84 - $ 0

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: V-4

TITLE: Provision of an Irradiated Fuel Verifier for Bruce-A Station

PARTICIPATING ORGANIZATIONS: AECL/AECB

IAEA PROJECT OFFICER:

PROBLEM:

Provision of irradiated fuel verifier suited to the Bruce A station storage bay. Such a device must be designed to suit the particular parameters of the bay.

PROPOSED SOLUTION:

The agency will be assisted to:

1) Determine IAEA requirements
2) Design verifier and tools
3) Construct verifier and tools
4) Install and test

SCHEDULE AND MILESTONES:

Begin April 1978.
Complete December 1986

PROGRESS:

1) A program has been initiated for the development and manufacture of an optical type verifier for the fuel bundles in the Bruce primary bay (Task V-6)
2) The development work concerning the Cerenkov verifier for spent fuel (Task V-8) indicates that such devices may also be applicable for this type of power station.

PLANNED COMPLETION DATE:

April 1986.

FUNDING:

Through 1983/84 - $ 48,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: V-6

TITLE: Development of an Optical Tool for Bruce-A Storage Bay

PARTICIPATING ORGANIZATIONS: AECL

IAEA PROJECT OFFICER:

PROBLEM:

The system studies safeguards scheme for the Bruce A power station recommended an optical tool as a back-up measure for the primary storage bay to verify the number of fuel bundles stored in the bay. The optical tool must be capable of detecting empty positions in stacked trays of irradiated fuel bundles.

PROPOSED SOLUTION:

To develop and demonstrate a tool which can detect whether or not a storage site is filled in any tray location in the Bruce A primary storage bay. Assistance will be provided to the agency to:

1) Design the tool
2) Produce a prototype tool
3) Test tool and demonstrate to the IAEA
4) Based on test and demonstration produce, install and commission an operational version of the tool.

SCHEDULE AND MILESTONES:

Start April 1981.
Complete December 1985.

PROGRESS:

A CCTV system has been designed for underwater use in which a camera can be placed between the stacks of fuel and indexed to view any bundle in the stack. The indexing mechanism has been constructed. The camera is currently undergoing tests in a spent fuel bay to determine its capabilities. The indexing mechanism has been tested out of bay. The entire system including camera must be tested and demonstrated to the IAEA.

PLANNED COMPLETION DATE:

December 1985

FUNDING:

Through 1983/84 - $ 27,000
1984/85 - $ 19,000
1985/86 - $ 20,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO.: V-8

TITLE: Application of Cerenkov Glow Amplification Techniques as an Attribute Test for Irradiated Fuel in 600 Mw CANDU Storage Bays.

PARTICIPATING ORGANIZATIONS: AECB/AECL

IAEA PROJECT OFFICER: S. Sanatini

PROBLEM:

Work on project V-7 has indicated that a technique which measures Cerenkov radiation has a good potential to satisfy the requirements of a spent fuel attribute test. The feasibility of, and a design for, the practical use of Cerenkov radiation techniques as a qualitative attribute test for unsealed irradiated fuel in 600 Mw CANDU spent fuel storage bays must be demonstrated under bay lighting conditions required for operational safety considerations.

PROPOSED SOLUTION:

1. Evaluate Cerenkov glow detection techniques that can be implemented under normal bay lighting conditions

2. Determine a performance specification for the Cerenkov Viewing Device (CVD) to be used in the 600 Mw CANDU safeguards scheme

3. Develop a CVD that will meet the performance specification

4. Write a report documenting the capabilities and limitations of the CVD

5. Provide design, operating, and maintenance manuals for the CVD

SCHEDULE AND MILESTONES:

Start April 1980
Complete March 1986

PROGRESS:

Tests at WNRE and at Bruce generating station show that freshly discharged (up to three months) fuel of nominal burn-up can be verified by visual inspection of the Cerenkov glow with the storage bay lights on. For fuel cooled longer than three months, a light intensifier is required.

A device was constructed and tested which consisted of a narrow band filter, a light intensifier and a 35 mm single lens reflex camera fitted with a telephoto lens. The narrow band filter screens out some of the scatter light from the facility lighting and the intensifier intensifies the Cerenkov glow so that it can be viewed. Further improvements

included the use of Lexan filters over the building lighting and a UV sensitive quartz lens for the light intensifier.

The performance specification has been proposed.

Two additional modifications have been made to the original prototype device. The first involves a different cathode material and the other a mirror lens rather than the quartz lens. When used in conjunction with the new cathode material, the mirror lens increases the sensitivity by a factor of 50-60 over the original prototype. The devices indicated that differences in Cerenkov glow of a factor of 3 can be readily observed in bundles grouped together in a tray. Differences of 7 could not be observed but differences of 5 or 6 appear feasible. Of those tested, the mirror lens is preferred for ease of operation.

PLANNED COMPLETION DATE:

December 1985

FUNDING:

Through 1983/84 - $352,000
1984/85 - $23,000
1985/86 - $59,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO.: V-9

TITLE: Application of Cerenkov Glow Amplification Techniques as an Attribute Test for Irradiated Fuel in Storage Bays.

PARTICIPATING ORGANIZATIONS: AECB/AECL

IAEA PROJECT OFFICER: S. Sanatini

PROBLEM:

Work on project V-7 has indicated that a technique which measures Cerenkov radiation has a good potential to satisfy the requirements of a spent fuel attribute test. Cerenkov Viewing Devices have been developed to detect the Cerenkov glow emitted from spent fuel. The further capabilities and limitations of these devices have not been established.

PROPOSED SOLUTIONS:

1. Calculate and validate theoretical Cerenkov glow intensities for various burn-ups and cooling times

2. Evaluate the CVDs with respect to spent CANDU fuel according to:

    a) sensitivity (cooling time and burnup)
    b) adjacent bundle interference
    c) lighting conditions
    d) ability to produce standardized results

3. Write a report describing the capabilities and limitations of the CVD as an attribute verifier for spent CANDU fuel

4. Provide recommendations for changes in CVD design

5. Provide design, operation, and maintenance manuals

6. Evaluate CVDs for spent fuel other than CANDU in applications agreed between Canada and the IAEA

SCHEDULE AND MILESTONES:

Begin March 1985
Complete June 1986 (proposed Solutions 1, 2, 3, 4, 5)

PROGRESS:

The work performed under task V-8 is applicable to this task. Under this task, the three devices developed under task V-8 will be evaluated in regard to their extended capabilities. Tests conducted at Douglas Point indicate that spent fuel could be detected with bay lights on after 11 years cooling if the bundle was isolated from other bundles.

FUNDING:

1985/86: $171, 000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: SC-5

TITLE: Development of a Multiplexed CCTV Surveillance System for the 600 MW CANDU Reactor

PARTICIPATING ORGANIZATIONS: AECL-CANDU OPS

IAEA PROJECT OFFICER: P. Vodrazka

PROBLEM:

When the CCTV system for the 600 MWe CANDU reactors was developed, video disc storage was usedto meet the specifications. The reliability of the equipment has proven to be unsatisfactory.

PROPOSED SOLUTION:

The technology for time lapse video recorders (TLR) now offers the opportunity to design a CCTV system that can be both more reliable and less expensive than the original system. A system based on TLRs will be developed.

SCHEDULE AND MILESTONES:

Start development : 1983
Demonstrate a prototype: 1985
Complete development : 1986
Complete documentation : 1986

PROGRESS:

The development is being carried out in two stages. First, TLRs are being field tested as back-ups to the existing CCTV systems at the 600 MWe reactors. Second, a multiplexed TLR system is being developed to replace the original system. The first prototype of the multiplexed system has been demonstrated to the Agency at the CANDU-Ops laboratory. During the current year improvments were made concerning picture quality and stability and ease of review by inspectors. A final prototype of the multiplexed CCTV record and playback system using three independent recording channels successfully passed preliminary IAEA testing in Canada. A MUX CCTV system was set-up in Vienna in March 1985 for thorough testing and inspector familiarization. A one channel MUX CCTV system was installed at one reactor facility for field trials. The trial has been successful except for a problem with clogging of the TLR read heads. This has been attributed to a defective tape.

PLANNED COMPLETION DATE:

1986

FUNDING:

Through 1983/84 - $ 180,000
1984/85 - $ 444,000
1985/86 - $ 222,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: SC-6

TITLE: Provision of a Multiplexed CCTV Surveillance System for four 600 MW CANDU Reactors

PARTICIPATING ORGANIZATIONS: AECL-CANDU OPS

IAEA PROJECT OFFICER: P. Vodrazka

PROBLEM:

The original CCTV systems installed at the 600 MWe CANDU reactors have been insufficiently reliable.

PROPOSED SOLUTION:

Replace the original CCTV systems with new ones based on multiplexed time lapse recorders. In the meantime, use TLRs as back-ups in the existing systems.

SCHEDULE AND MILESTONES:

Install back-up TLRs : 1984
Replace original systems with multiplexed TLR systems: 1986

PROGRESS:

The back-up TLRs have been installed.

PLANNED COMPLETION DATE:

1986

FUNDING:

Through 1983/84 - $ 0
1984/85 - $ 26,000
1985/86 - $ 119,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: SC-7

TITLE: Surveillance System for 200 MW Fuelling Machine Room

PARTICIPATING ORGANIZATIONS: IAEA/AECL/AECB

IAEA PROJECT OFFICER:

PROBLEM:

The IAEA has identified a need to detect abnormal fuel transfers in the fuelling machine room of 200 Mw reactors and to correlate this information with other safeguards information.

PROPOSED SOLUTION:

Investigate the use of surveillance in the 200 MW CANDU fuelling machine room by examining such possibilities as periscopes, telescopes, wide angle lenses, fibreoptics, CCTV, film cameras etc. Problems of inaccessibility of the fuelling machine vaults while the reactor is operating must be considered.

SCHEDULE AND MILESTONES:

Start task:	December 1984
Complete investigation:	October 1985
Write report:	November 1985

PLANNED COMPLETION DATE:

1985

FUNDING:

$10,000.00

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: FF-4

TITLE: Provision of Fresh Fuel Counters for the Bruce-A CANDU Station

PARTICIPATING ORGANIZATIONS: AECL

IAEA PROJECT OFFICER:

PROBLEM:

The IAEA requires four fresh fuel counters for the Bruce type CANDU generating station.

PROPOSED SOLUTION:

To assist the IAEA to produce fresh fuel counters for the Bruce generating station. Four production fresh fuel counters will be constructed.

SCHEDULE AND MILESTONES:

Begin January 1984

PROGRESS:

Four fresh fuel counters have been manufactured and will be installed upon IAEA acceptance of the production prototype (FF-3).

PLANNED COMPLETION DATE:

December 1985

FUNDING:

Through 1983/84 -	$	65,000
1984/85 -	$	4,000
1985/86 -	$	10,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: FF-5

TITLE: Fresh Fuel Verifier

PARTICIPATING ORGANIZATIONS: IAEA/AECB/AECL

IAEA PROJECT OFFICER:

PROBLEM:

The IAEA has identified a need to verify the item count of fresh fuel stored in boxes without the need to open boxes or remove them from their storage locations.

PROPOSED SOLUTION:

1) Perform a feasibility study to determine a method to verify the item count of fresh fuel in boxes without opening the boxes or removing them from their storage locations

If 1) yields positive results

2) Develop a laboratory prototype instrument to perform the verification
3) Demonstrate prototype to IAEA

SCHEDULE AND MILESTONES:

1) Perform feasibility study to identify possible solutions
2) Evaluate the solutions giving priority to those that use IAEA instrumentation accepted for routine use
3) Write a report of the finding of 1) and 2)

If feasible

4) Develop a laboratory prototype
5) Demonstrate prototype to IAEA
6) Document the work, including operating and maintenance manuals
7) Deliver prototypes to IAEA for evaluation

PLANNED COMPLETION DATE:

Complete feasibility study 1986

FUNDING:

TBD

MISCELLANEOUS

The tasks which appear in this section are those which do not logically fall into the previous three program areas although they may be of equal importance. This section includes the provision of physical standards, engineering and technical support and various feasibility studies.

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: PS-1

TITLE: Provision of Physical Standards

PARTICIPATING ORGANIZATIONS: AECB/AECL

IAEA PROJECT OFFICER:

PROBLEM:

The IAEA requires access to nuclear material standards in order to provide the basis for measurements made during the course of its verifications.

PROPOSED SOLUTION:

Provide standards or facilities for measurement of standard items.

SCHEDULE AND MILESTONES:

As required

PROGRESS:

The IAEA requested and the Support Program provided two dummy CANDU fuel bundles.

PLANNED COMPLETION DATE:

On-going

FUNDING:

Through 1983/84	- $	2,000
1984/85	- $	0
1985/86	- $	0

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: TS-1

TITLE: Provision of Scientific and Engineering Technical Support

PARTICIPATING ORGANIZATIONS: AECB/AECL

IAEA PROJECT OFFICER:

PROBLEM:

The application of new concepts and new techniques to safeguards often requires testing and development before a prototypical instrument or installation can be designed and, in many cases, this requires sophisticated practical instrumentation. The IAEA needs Canadian assistance when such concept testing must be undertaken under conditions in which Canada has unique expertise.

PROPOSED SOLUTION:

1) Upon request, consult with the IAEA to identify the requirements of the concept testing/demonstration
2) In consultation with the IAEA make the necessary arrangements to conduct the tests/demonstration
3) Undertake the test/demonstration
4) Report results

SCHEDULE AND MILESTONES:

As required

PROGRESS:

Several requests have been received from the IAEA and the requirements have often developed into individual tasks. Tasks which are included under TS-1 are as follows:

The Use of Radiochromic Materials to Verify CANDU Spent Fuel

A study has been conducted to determine the value of using radiochromic materials to verify CANDU spent fuel in spent fuel bays. The results obtained indicate that Polaroid film can be used as a fuel verifier for single bundles but that there is enough general radiation scattering that a dummy could not be detected in an array of spent fuel bundles. A report has been issued and the task completed.

FUNDING:

Through 1983/84 - $ 85,000

RECOVER

At the request of the IAEA Canada has participated in a long-term test of the RECOVER system. This test involved the fibre optic seal on the spent fuel canisters and is now completed.

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

FUNDING:

Through 1983/84 - $ 6,000

Core Input Monitor Feasibility Studies

Studies have been undertaken to determine the feasibility of installing core input monitors in Pickering A Generating Station. Work has been postponed pending IAEA reexamination of the safeguards scheme.

PLANNED COMPLETION DATE:

TBD

FUNDING:

Through 1983/84 - $ 13,000

Performance Monitoring Program

Because much of the equipment installed in the 600 MW reactors was not able to be environmentally tested prior to installation, a performance monitoring program was initiated to provide information on the reliability of the instrumentation in operating reactors. This work was primarily performed by cost-free experts and personnel from the Division of Development and Technical Support of the IAEA in the early stages. The information will eventually be gathered by inspectors and analyzed by IAEA staff.

FUNDING:

Through 1983/84 - $ 112,000
1984/85 - $ 68,000
1985-86 - $ 80,000

COMPLETE OR TERMINATED TASKS

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: CFE-4

TITLE: Documentation Specialist and Heavy Water Instrumentation Expert

PARTICIPATING ORGANIZATIONS: AECL/AECB

IAEA PROJECT OFFICER: E. Kerr

PROBLEM:

The IAEA requested assistance in setting up a documentation storage and retrieval system with respect to the technical material - drawings, manuals, and specifications - that are associated with the equipment developed by the support programs for the IAEA and assistance relating to the safeguards of heavy water at reactors and storage facilities.

PROPOSED SOLUTION:

Supply a cost-free expert to serve on IAEA staff to:

1) Set up a technical document storage and retrieval system suitable for computer usage.
2) Advise and collaborate with IAEA staff in the development of methods for verifying the heavy water inventory at reactors and storage locations.

SCHEDULE AND MILESTONES:

A cost-free expert to begin a one-year assignment in October, 1984.

PROGRESS:

The expert completed the documentation task by identifying all those documents held by the IAEA associated with tasks performed by the Canada/IAEA Safeguards Support Program. A list of those documents not held by the IAEA was prepared and distributed to Canadian authorities for subsequent transmittal of these documents to the IAEA. A document indexing system was established. Recommendations for a document storage and retrieval system was presented to the IAEA. It was decided that other approaches would be used to provide the assistance on heavy water safeguards rather than use the services of a CFE.

PLANNED COMPLETION DATE:

Complete February 1985

FUNDING:

1984/85 - $ 29,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: S-1

TITLE: Development of a Safeguards Scheme for 125 MW CANDU Reactors

PARTICIPATING ORGANIZATIONS: AECB

IAEA PROJECT OFFICER:

PROBLEM:

A design for a safeguard system for 125 MWe CANDU reactors is needed as a complement to IAEA accounting activities to provide comprehensive safeguards for such reactor facilities.

PROPOSED SOLUTION:

To assist the IAEA to:

1) Compile design information
2) Produce a diversion path analysis
3) Produce a total safeguards scheme for the facility
4) Determine the equipment required for upgrading of safeguards at these facilities

SCHEDULE AND MILESTONES:

Begin January, 1981

PROGRESS:

1) a safeguards scheme was produced and a report drafted by the IAEA
2) an irradiated fuel bundle counter has been developed and shipped to the IAEA for use in this reactor type
3) a sealing system was designed by the IAEA and a prototype constructed and tested in collaboration with AECL

PLANNED COMPLETION DATE:

April, 1983

FUNDING:

Through 1983/84 - $ 50,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: S-3

TITLE: Development of a Safeguards Scheme for 200 MW CANDU reactors

PARTICIPATING ORGANIZATIONS: AECB

IAEA PROJECT OFFICER: W. Bahm

PROBLEM:

A design for an integrated safeguard system is needed as a complement to current IAEA inspection activities to provide comprehensive safeguards for 200 MWe CANDU reactors.

PROPOSED SOLUTION:

Assist the IAEA to:

1) Compile design information
2) Produce a diversion analysis
3) Produce a safeguard scheme
4) Determine the equipment required for upgrading of safeguards in this reactor type.

SCHEDULE AND MILESTONES:

Begin July, 1981, complete December 1983

PROGRESS:

The IAEA has been supplied with a diversion path analysis for these reactor types. The IAEA project officer for this task visited Canada in 1981 to study this reactor. Recommendations were made for upgrading of safeguards in this type of reactor in an IAEA internal report.

PLANNED COMPLETION DATE:

Complete

FUNDING:

Through 1983/84 - $ 43,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: S-4

TITLE: Development of a Safeguards Scheme for Bruce-A Station

PARTICIPATING ORGANIZATIONS: AECB

IAEA PROJECT OFFICER:

PROBLEM:

A design for an integrated safeguard system for the Bruce A CANDU power station is needed as a complement to current IAEA inspection activities to provide comprehensive safeguards for the Bruce A reactor facility.

PROPOSED SOLUTION:

Assist the IAEA to:

1) Compile design information
2) Produce a diversion path analysis
3) Provide technical assistance to the IAEA as needed including feasibility studies
4) Produce a safeguard scheme

SCHEDULE AND MILESTONES:

Begin April 1, 1979, complete March 1981

PROGRESS:

The safeguards equipment feasibility study was completed and sent to the IAEA. A diversion path analysis was sent to the IAEA. The proposed safeguard scheme has been prepared by the IAEA. Development work was indicated as being required on core input monitors, bundle counters, seals for spent fuel, Cerenkov verifiers and an optical verifier for checking of fuel in the primary storage bay.

PLANNED COMPLETION DATE:

Complete

FUNDING:

Through 1983/84 - $ 80,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: S-5

TITLE: Development of a Safeguards Scheme for Pickering-A Station

PARTICIPATING ORGANIZATIONS: AECB

IAEA PROJECT OFFICER:

PROBLEM:

A design for an integrated safeguards system is needed as a complement to current IAEA accounting activities to provide comprehensive safeguards for the Pickering A reactor facility.

PROPOSED SOLUTION:

Assist the IAEA to:

1) Compile design information
2) Produce a diversion path analysis
3) Provide technical assistance to the IAEA as needed including feasibility studies
4) Produce a safeguards scheme for the facility

SCHEDULE AND MILESTONES:

Begin April 1, 1980, complete March, 1981

PROGRESS:

The IAEA indicated a feasibility study of existing safeguards equipment would be required and that a diversion path analysis would not be needed. The IAEA were provided with all design information required for the development of a safeguards scheme. A proposed safeguards scheme has been prepared. Development of bundle counter electronics and underwater seal for spent fuel were recommended in the proposed scheme.

PLANNED COMPLETION DATE:

Complete

FUNDING:

Through 1983/84 - $ 5,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: S-6

TITLE: Development of a Safeguards Scheme for WR-1-type Reactors

PARTICIPATING ORGANIZATIONS: AECB/AECL

IAEA PROJECT OFFICER: W. Bahm

PROBLEM:

A design for an integrated safeguard system for WR-1-type organic CANDU reactors is needed as a complement to IAEA inspection activities to provide comprehensive safeguards for this reactor type.

PROPOSED SOLUTION:

Assist the IAEA to:

1) Compile design information
2) Produce a diversion path analysis
3) Provide technical assistance to the IAEA as needed including feasibility studies
4) Produce a safeguards scheme
5) Make recommendations regarding equipment to be used in conjunction with the safeguard scheme

SCHEDULE AND MILESTONES:

Begin September, 1981, complete July, 1985

PROGRESS:

Design information has been compiled and sent to the IAEA. The IAEA project officer for this task visited Canada in 1981 to study this type of reactor. A review of design information was undertaken by CFE-1 in June, 1983. This task has been terminated since no WR-1 type reactor will be in service after 1985.

PLANNED COMPLETION DATE:

Terminated

FUNDING:

Through 1983/84 - $ 3,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: B-1

TITLE: Development of a Bundle Counter for the 600 MW CANDU Reactors

PARTICIPATING ORGANIZATIONS: AECL-CRNL

IAEA PROJECT OFFICER: A. Keddar

PROBLEM:

The Agency needs assurance that the number of fuel bundles discharged from the core of a 600 MW CANDU reactor and transferred to the spent fuel storage bay is in agreement with the operator's records.

PROPOSED SOLUTION:

Develop a spent fuel bundle counter suitable for the 600 MW CANDU reactor.

SCHEDULE AND MILESTONES:

Start development	:	1977
Complete development	:	1982
Complete documentation	:	1982

PROGRESS:

A suitable bundle counter has been developed and demonstrated to the Agency. Detailed design and operating documentation have been completed.

PLANNED COMPLETION DATE:

Complete 1982

FUNDING:

Through 1983/84 - $ 840,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: V-1

TITLE: Development of an Irradiated Fuel Verifier for 600 MW CANDU Reactors

PARTICIPATING ORGANIZATIONS: AECL

IAEA PROJECT OFFICER:

PROBLEM:

In order to determine that no diversion of irradiated fuel has occurred from the storage bay the IAEA must be able to count the number of bundle-like objects in the bay and to verify that these are highly irradiated. This task encompasses the generic work required to develop an irradiated fuel verifier for the 600 MWe type CANDU reactor.

PROPOSED SOLUTION:

1) Determine IAEA requirements
2) Design prototype verifier and tools
3) Construct prototype verifier
4) Demonstrate

SCHEDULE AND MILESTONES:

Begin June, 1979, complete June, 1982

PROGRESS:

The design of an irradiated fuel verifier was based on the principle of verifying gross gamma emission characteristics of the fuel. Assessment was also made of the relative merits of using Cerenkov radiation as a substitute technique to replace the gross gamma verifier. Preliminary results indicated that Cerenkov radiation would be a good attribute to verify. A verifier has been developed which tests for Cerenkov emission rather than gross gamma emission. This task has been terminated.

PLANNED COMPLETION DATE:

Completed

FUNDING:

Through 1983/84 - $ 48,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: V-5

TITLE: Provision of an Irradiated Fuel Verifier for Pickering-A Station

PARTICIPATING ORGANIZATIONS: AECL/AECB

IAEA PROJECT OFFICER:

PROBLEM:

Irradiated fuel at Pickering A station must be verified.

PROPOSED SOLUTION:

Produce an irradiated fuel verifier suited to the Pickering A station storage bay. Assistance will be provided to the IAEA to:

1) Determine the IAEA requirements
2) Design verifier and tools
3) Construct verifier and tools
4) Install and test verifier

SCHEDULE AND MILESTONES:

Start August 1977, complete August 1978

PROGRESS:

A gross gamma-type irradiated fuel verifier has been completed, installed and is now being used. Some modifications have been made based on suggestions after operating experience with the verifier.

PLANNED COMPLETION DATE:

Completed

FUNDING:

Through 1983/84 - $ 90,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: V-7

TITLE: Evaluation of Light Amplification Techniques Applied to Cerenkov Glow as an Attribute Test for Irradiated CANDU Fuel

PARTICIPATING ORGANIZATIONS: AECL

IAEA PROJECT OFFICER: S. Sanatani

PROBLEM:

The IAEA requires a system that will determine whether or not bundles in the spent fuel bay are irradiated CANDU fuel bundles. The ideal system will result in a minimum disruption of the operator's program of fuel handling. The light amplification techniques utilizing Cerenkov radiation need to be tested to determine their effectiveness when applied to CANDU fuel bundles.

PROPOSED SOLUTION:

To assist the IAEA to evaluate the effectiveness of techniques using the amplification of light from Cerenkov radiation for determining whether bundles in a spent fuel bay are irradiated CANDU bundles. This is to be done for the normal storage conditions, i.e. bundles in both single and stacked storage trays in spent fuel bays. Assistance will be provided to the IAEA in:

1) Arranging for suitable testing of the approach for various bundle stacking arrangements which exist in CANDU stations
2) Assessing, if possible, quantitative measurements of fuel bundles using this method
3) Preparing a report on the effectiveness and possible use by the Agency of this technique for determining if the bundles are actually irradiated fuel bundles and its applicability for quantitative analysis

SCHEDULE AND MILESTONES:

Begin January 1980, complete July 1981

PROGRESS:

Assistance was provided at CRNL to demonstrate the application of Cerenkov radiation verification techniques to CANDU fuel. The results of Task V-7 indicate that Cerenkov radiation could be used as an attribute verification if trays of bundles are isolated from stacks. Work on Cerenkov radiation for use in verifying irradiated fuel in 600 MWe reactors is presently being done under the terms of Task V-8. Further work involving amplification techniques is concentrated in Task V-9.

PLANNED COMPLETION DATE:

Complete

FUNDING:
Through 1983/84 - $ 22,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: SC-1

TITLE: Development of CCTV Surveillance System for the 600 MW CANDU Reactor

PARTICIPATING ORGANIZATIONS: AECL-CANDU OPS

IAEA PROJECT OFFICER: P. Vodrazka

PROBLEM:

Surveillance is one of the prime elements in the application of safeguards at 600 MWe CANDU stations. Some areas require CCTV rather than film cameras.

PROPOSED SOLUTION:

Develop a CCTV system suitable for use at 600 MWe CANDUs.

SCHEDULE AND MILESTONES:

Start development : 1978
Complete development : 1982
Complete documentation: 1983

PROGRESS:

A computer controlled system was developed in which the signals from eight TV cameras were stored at intervals on a disc recorder and then transferred to cassette recorders. Redundancy was built in to cope with equipment failures.

PLANNED COMPLETION DATE:

Complete 1983

FUNDING:

Through 1983/84 - $ 690,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: SC-2

TITLE: Provision of CCTV Surveillance System for four 600 MW CANDU Reactors

PARTICIPATING ORGANIZATIONS: AECL-CANDU OPS

IAEA PROJECT OFFICER: P. Vodrazka

PROBLEM:

CCTV surveillance is required as part of the application of safeguards at the 600 MWe CANDU stations.

PROPOSED SOLUTION:

Provide a CCTV system suitable for each 600 MWe CANDU station.

SCHEDULE AND MILESTONES:

Complete manufacture : 1982
Complete installation: 1983

PROGRESS:

A CCTV system was installed at each of the four 600 MWe CANDU stations. The performance is adequate for safeguards when the system functions according to design. However, equipment reliability has been a problem. Remedial action is being taken under other tasks.

PLANNED COMPLETION DATE:

Complete - 1983

FUNDING:

Through 1983/84 - $ 1,440,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: SC-3

TITLE: Development of Photo-Surveillance Cameras for the 600 MW CANDU Reactor

PARTICIPATING ORGANIZATIONS: AECL-CANDU OPS

IAEA PROJECT OFFICER: P. Vodrazka

PROBLEM:

Surveillance is one of the prime elements in the application of safeguards at 600 MWe CANDU reactors. Film cameras are suitable for use in some areas.

PROPOSED SOLUTION:

Develop a film camera system that will take photographs automatically at intervals as required.

SCHEDULE AND MILESTONES:

Start Development: 1978

PROGRESS:

A system was developed based on the use of a single 8 mm motion picture camera modified for single frame exposures triggered by fixed and random interval timers and by motion and gamma detectors.

Development stopped before the motion and gamma detectors were fully developed, because the Agency decided that these do not form a satisfactory basis for producing safeguards records. Used as a fixed-time triggered unit, the single camera is less reliable than Agency twin Minoltas.

PLANNED COMPLETION DATE:

Complete - 1983

FUNDING:

Through 1983/84 - $ 280,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: SC-4

TITLE: Provision of Photo-Surveillance Cameras for four 600 MW CANDU Reactors

PARTICIPATING ORGANIZATIONS: AECL-CANDU OPS

IAEA PROJECT OFFICER: P. Vodrazka

PROBLEM:

Film cameras are required as part of the application of safeguards at the 600 MWe CANDU stations.

PROPOSED SOLUTION:

Provide film cameras for each 600 MWe CANDU station.

SCHEDULE AND MILESTONES:

Complete manufacture : 1982
Complete installation: 1983

PROGRESS:

The film cameras were installed at all four stations. They have proven to be less reliable than the Agency twin Minolta systems. The motion and gamma triggering were not included because they had not yet been fully developed. For these reasons, the Agency has replaced the Canadian supplied cameras with their twin Minolta systems.
1984/85 Spare cameras shipped to IAEA.

PLANNED COMPLETION DATE:

Complete - 1984

FUNDING:

Through 1983/84 - $ 240,000
1984/85 - $ 2,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: FF-1

TITLE: Development of a Fresh Fuel Interrogation Concept for the CANDU Reactor

PARTICIPATING ORGANIZATIONS: AECL

IAEA PROJECT OFFICER:

PROBLEM:

Development of a fresh fuel interrogator to verify the flow of fresh fuel into the reactor core could be an asset in safeguarding CANDU reactors.

PROPOSED SOLUTION:

Investigate the physical principles to verify the flow of fresh fuel into the core and demonstrate a device in a laboratory situation. Assistance will be provided to the Agency to:

1) Determine the physical attribute to be monitored
2) Determine the strategy of counting and recording
3) Assemble laboratory equipment
4) Demonstrate a device

SCHEDULE AND MILESTONES:

Begin April 1978

PROGRESS:

A feasibility study on the fresh fuel interrogation concept was performed and a report was made to the IAEA. The fresh fuel interrogator was rejected in favor of a simple counting device for the following reasons:

1) extremely high cost
2) difficulty of retro-fitting reactors
3) information to be gained from the device did not appear to be of high enough quality as to be very useful

Work proceeded on development of a fresh fuel counter in task FF-3.

PLANNED COMPLETION DATE:

Complete

FUNDING:

Through 1983/84 - $ 29,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: FF-2

TITLE: Demonstration of a Fresh Fuel Interrogator in a CANDU Reactor

PARTICIPATING ORGANIZATIONS: AECL

IAEA PROJECT OFFICER:

PROBLEM:

Using the principles of operation demonstrated in FF-1, a prototype will be designed, constructed, commissioned and tested provided the results of FF-1 are positive enough to justify continuing this development.

PROPOSED SOLUTION:

To construct and demonstrate a prototype fresh fuel interrogator. Assistance will be provided to the IAEA to:

1) Design an interrogator
2) Construct an interrogator
3) Conduct operational tests

SCHEDULE AND MILESTONES:

Cancelled

PROGRESS:

This task has been cancelled because of the negative results of task FF-1.

PLANNED COMPLETION DATE:

Cancelled

FUNDING:

Through 1983/84 - $ 0

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: FF-3

TITLE: Development of a Prototype Fresh Fuel Counter for the Bruce-type CANDU Reactor

PARTICIPATING ORGANIZATIONS: AECL

IAEA PROJECT OFFICER:

PROBLEM:

The IAEA considers that the ability to independently verify the declared flow of fuel charged into the reactor cores for the Bruce type CANDU reactor would constitute an improvement in the safeguarding of both fresh and irradiated fuel for this type of CANDU reactor.

PROPOSED SOLUTION:

Develop and demonstrate a simple counter that could be attached to the fresh fuel loading machine to count the number of fuel bundles charged into the fuelling machine. The device would have some tamper indicating features. The agency would be assisted to:

1) Design the counter
2) Produce a prototype counter
3) Test the counter in as realistic manner as possible in a laboratory environment
4) Install a production prototype at the reactor for field trials

SCHEDULE AND MILESTONES:

Begin December 1979, complete July 1984

PROGRESS:

Preliminary testing and development work has been completed. Laboratory models have been produced and tested satisfactorily. A prototype was constructed and demonstrated to the IAEA in February 1981. Suggestions for minor improvements were completed and the unit was re-demonstrated at IAEA headquarters, Vienna, in March 1981. A report has been written describing the monitor and the results of the laboratory tests. The final version of the prototype monitor has been constructed and demonstrated. The production prototype underwent field tests from April to July 1984. Documentation for the device has been completed.

PLANNED COMPLETION DATE:

Complete - August 1984

FUNDING:

Through 1983/84 - $ 320,000
1984/85 - $ 36,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: HW-1

TITLE: Study to Investigate the Safeguards of Heavy Water

PARTICIPATING ORGANIZATIONS: AECB-AECL

IAEA PROJECT OFFICER:

PROBLEM:

Heavy water is one of several moderators that can be used in a reactor thereby indirectly contributing to the production of fissile material.

PROPOSED SOLUTION:

Assist the IAEA to:

1) Determine how heavy water is normally used and handled in operating power reactors
2) Establish criteria for the verification methods
3) Enumerate in detail verification methods, procedures and instrumentation

SCHEDULE AND MILESTONES:

Begin August 1977
Complete September 1980.

PROGRESS:

A study was completed. A report was written and sent to the IAEA on this subject. The study is now considered complete.

PLANNED COMPLETION DATE:

Complete

FUNDING:

Through 1983/84 - $ 12,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: OR-1

TITLE: Study of the Use of Reactor Operating Records and Instrument Data for Verification of the Declared Core Inventory and the Flow of Fuel Through the Core

PARTICIPATING ORGANIZATIONS: AECL/Ontario Hydro

IAEA PROJECT OFFICER:

PROBLEM:

Nuclear material in the core of CANDU reactors is inaccessible and cannot be directly verified with any of the normal techniques available to IAEA inspectors. Process parameters may be useful for qualitative determination of the core inventory or fuelling operations. A study of the use of reactor operating records and instrument data is required to determine their applicability to the verification of the declared core inventory and the flow of fuel through the core.

PROPOSED SOLUTION:

Phase 1

1) Determine what instrument data or core parameters are available and could be provided to the IAEA inspectors
2) Determine the usefulness of each data type, either singly or in combinations, providing a qualitative indication of core inventory for fuelling operations
3) Determine the sensitivity of the indications given including effects on the data from typical operation conditions and whether such effects can be overcome

Phase 2

1) Determine how the data identified in Phase 1 can be obtained, managed and digested and presented to the IAEA inspectors
2) Identify methods of verifying the data identified in Phase 1
3) Estimate the manpower required to use the data effectively

SCHEDULE AND MILESTONES:

Begin July 1981

PROGRESS:

Phase 1 of the task has been completed, a draft report has been written and sent to the IAEA for comment, comments have been made by the IAEA and were considered by Canadian experts. The task is considered complete.

PLANNED COMPLETION DATE:

Complete 1985

FUNDING:

Through 1983/84 - $ 31,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: CV-1

TITLE: Verification of the Fuel Inventory Contained in a Reactor Core

PARTICIPATING ORGANIZATIONS: AECL/Ontario Hydro

IAEA PROJECT OFFICER:

PROBLEM:

The IAEA has proposed the discharge of a statistically significant number of fuel channels to verify the number of fuel bundles contained in a CANDU reactor core. An examination of the technical feasibility and cost involved in this approach is required.

PROPOSED SOLUTION:

Study the technical, operational and economic implications of the proposal to verify the fuel inventory contained in a CANDU reactor core.

SCHEDULE AND MILESTONES:

Begin April 1981, complete November 1982

PROGRESS:

A draft report has been completed and issued to the IAEA regarding these findings. The report proposes two methods for the verification of the reactor core. One method involves the discharge of a statistically selected number of fuel channels to verify the number of fuel bundles contained in the core. The second method proposes a statistical sample plan to verify the core but the actual verification of fuel bundles occurs only when the selected channel is discharged according to the regular fuelling schedule. After discharge the irradiation history of the bundles would be determined to verify the operator's records by using NDA techniques.

PLANNED COMPLETION DATE:

Complete

FUNDING:

Through 1983/84 - $ 24,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: FM-1

TITLE: Study to Investigate Means of Determining the Fissile Material Content of Spent Fuel Bundles

PARTICIPATING ORGANIZATIONS: AECL

IAEA PROJECT OFFICER:

PROBLEM:

As a back-up measure to the primary containment and surveillance measures at irradiated fuel storage bay for CANDU power stations, the Agency may require a method to determine the fissile material content of irradiated fuel bundles.

PROPOSED SOLUTION:

Determine a practical inspection method for determining the fissile material content of spent fuel CANDU bundles. Provide assistance to the IAEA to:

1) Identify potential methods
2) Evaluate the potential methods for accuracy, ease of application, hardware cost, obtrusiveness, vulnerability, etc.
3) Develop a technique and design for the most promising method

SCHEDULE AND MILESTONES:

Begin September 1978
Complete January 1980

PROGRESS:

A report was written and sent to the IAEA. The results of the study for points one and two indicated that there was no further development required beyond Agency techniques currently practiced. The task is complete.

PLANNED COMPLETION DATE:

Completed

FUNDING:

Through 1983/84 - $ 3,000

CANADIAN SAFEGUARDS R & D IN SUPPORT OF IAEA

TASK NO: SS-1

TITLE: Study to Investigate Unique CANDU Bundle Identification

PARTICIPATING ORGANIZATIONS: AECL

IAEA PROJECT OFFICER:

PROBLEM:

The current safeguards approaches for CANDU reactors entail the use of containment and surveillance to counter many of the diversion paths. The Agency felt that a unique identification of each CANDU bundle would establish accountancy as a prime safeguards tool and possibly reduce the safeguards cost and effort from the containment and surveillance approach. A study is required to determine the feasibility of unique CANDU bundle identifiers.

PROPOSED SOLUTION:

1) Review the state-of-the-art of unique identifier concept, especially ultrasonic pattern recognition of inclusion in welds
2) Consider means to incorporate unique identifiers as integral components of each fuel bundle. Estimate the incremental manufacturing cost associated with the operation. Assess potential safety problems associated with the addition of the identification through the life cycle of the fuel bundles
3) Determine engineering specifications for readers, including bundle handling requirements. Include a data file generator noting, as a minimum, reader identity, identity pattern observed, date, and time of reading. Estimate cost per unit including development. Consider schemes to read bundle identifiers in-situ, storage racks
4) Estimate the requirements, cost and times for a pilot test program
5) Prepare a summary report

SCHEDULE AND MILESTONES:

Begin June 1978

PROGRESS:

The study on unique CANDU bundle identification has been completed and a copy of the report sent to the IAEA. The result of the report is that the techniques studied were not feasible to use in unique CANDU bundle identification. The task is considered complete.

PLANNED COMPLETION DATE:

Complete

FUNDING:

Through 1983/84 - $ 13,000